

WHAT IS CLAIMED IS:

1 1. A method for decoding symbols transmitted in a multi-input multi-
2 output communications system having M_t transmit antennas and M_r receive antennas, the
3 symbols transmitted via a channel having an associated matrix \mathbf{H} with M_t rows and M_r
4 columns, the method comprising:

5 receiving a vector \mathbf{r} of the transmitted symbols on the M_r receive antennas,
6 wherein the vector \mathbf{r} has M_r components;

7 thereafter forming a first vector quantity \mathbf{xopt}_1 , associated with a first one of
8 the transmit antennas and having elements defined by a column \mathbf{h}_1 of matrix \mathbf{H} associated
9 with the first antenna, the remaining columns $\mathbf{H}_{n \neq 1}$ of matrix \mathbf{H} , and a matrix \mathbf{X} of possible
10 symbols transmitted on the remaining ones of the transmit antennas, wherein matrix \mathbf{X}
11 includes $(M_t - 1)$ rows and 2^{u+n} columns, wherein each transmitted symbol is selected from 2^n
12 cosets each having 2^u labels, wherein n and u each is an integer greater than zero;

13 thereafter finding a distance metric and a label metric associated with each of
14 the remaining transmit antennas for each coset based on \mathbf{xopt}_1 ;

15 thereafter forming a second vector quantity \mathbf{xopt}_2 associated with a second
16 one of the transmit antennas and having elements defined by a column \mathbf{h}_2 of matrix \mathbf{H}
17 associated with the second antenna, the remaining columns $\mathbf{H}_{n \neq 2}$ of matrix \mathbf{H} , and the matrix
18 \mathbf{X} ; and

19 thereafter finding a distance metric and a label metric associated with the first
20 one of the transmit antennas for each coset based on \mathbf{xopt}_2 .

1 2. The method of claim 1, wherein the first vector quantity \mathbf{xopt}_1 is
2 defined by:

$$3 \quad \mathbf{xopt}_1 = \left[\frac{\Lambda^{-1} (\mathbf{h}_1^* \mathbf{r} - \mathbf{h}_1^* \mathbf{H}_{n \neq 1} \mathbf{X})}{\mathbf{h}_1^* \mathbf{h}_1} \right]$$

4 wherein vector \mathbf{h}_1^* is the complex conjugate transpose of vector \mathbf{h}_1 , and Λ^{-1} is an auto-
5 covariance matrix of any of the transmit antennas.

1 3. The method of claim 1, wherein the second vector quantity \mathbf{xopt}_2 is
2 defined by:

3

$$\mathbf{xopt}_2 = \left[\frac{\Lambda^{-1} (\mathbf{h}_2^* \mathbf{r} - \mathbf{h}_2^* \mathbf{H}_{n=2} \mathbf{X})}{\mathbf{h}_2^* \mathbf{h}_2} \right]$$

4 wherein vector \mathbf{h}_2^* is the complex conjugate transpose of vector \mathbf{h}_2 and Λ^{-1} is an auto-
5 covariance matrix of any of the transmit antennas.

1 4. The method of claim 1, wherein for coset j, the distance metric
2 associated with transmit antenna i is defined by:

3

$$4 d(i, j) = \min_k (\mathbf{r} - \mathbf{h}_i \mathbf{xopt}_i(k) - \mathbf{H}_{n=1} \mathbf{X}(k))^H \Lambda^{-1} (\mathbf{r} - \mathbf{h}_i \mathbf{xopt}_i(k) - \mathbf{H}_{n=1} \mathbf{X}(k))$$

5

6 wherein i represents one of the transmit antennas other than the first antenna, j represents one
7 of the 2^n cosets, k represents one of the 2^u labels of coset j, $\mathbf{H}_{n=1}$ is a matrix of the columns of
8 \mathbf{H} except the first column of matrix \mathbf{H} , Λ^{-1} is an auto-covariance matrix of any of the
9 transmit antennas, $\mathbf{X}(k)$ represents all rows of matrix \mathbf{X} which have an element of coset k in
10 their i^{th} column, and $\mathbf{xopt}_i(k)$ represents those elements of vector \mathbf{xopt}_i that belong to coset
11 k.

1 5. The method of claim 1, wherein for coset j, the label metric associated
2 with transmit antenna i is defined by:

3

$$4 label(i, j) = \arg \min_k (\mathbf{r} - \mathbf{h}_i \mathbf{xopt}_i(k) - \mathbf{H}_{n=1} \mathbf{X}(k))^H \Lambda^{-1} (\mathbf{r} - \mathbf{h}_i \mathbf{xopt}_i(k) - \mathbf{H}_{n=1} \mathbf{X}(k))$$

5

6 wherein i represents one of the transmit antennas other than the first antenna, j represents one
7 of the 2^n cosets, k represents one of the 2^u labels of coset j, $\mathbf{H}_{n=1}$ is a matrix of the columns of
8 \mathbf{H} except the first column of matrix \mathbf{H} , Λ^{-1} is an auto-covariance matrix of any of the
9 transmit antennas, $\mathbf{X}(k)$ represents all rows of matrix \mathbf{X} which have an element of coset k in
10 their i^{th} column, and $\mathbf{xopt}_i(k)$ represents those elements of vector \mathbf{xopt}_i that belong to coset
11 k.

1 6. The method of claim 1, wherein for coset j, the distance metric
2 associated with the first one of the transmit antennas is defined by:

4 $d(1, j) = \min_k (\mathbf{r} - \mathbf{h}_2 \mathbf{xopt}_2(k) - \mathbf{H}_{n \neq 2} \mathbf{X}(k))^H \Lambda^{-1} (\mathbf{r} - \mathbf{h}_2 \mathbf{xopt}_2(k) - \mathbf{H}_{n \neq 2} \mathbf{X}(k))$

5
6 wherein j represents one of the 2^n cosets, k represents one of the 2^u labels of coset j , \mathbf{h}_2 is the
7 second column of matrix \mathbf{H} , $\mathbf{H}_{n \neq 2}$ is a matrix of the columns of \mathbf{H} except the second column
8 of matrix \mathbf{H} , Λ^{-1} is an auto-covariance matrix of any of the transmit antennas, and
9 $\mathbf{X}(k)$ represents all rows of matrix \mathbf{X} which have an element of coset k in their 1st column.

1 7. The method of claim 1, wherein for coset j , the label metric associated
2 with the first one of the transmit antennas is defined by:

3
4 $label(1, j) = \arg \min_k (\mathbf{r} - \mathbf{h}_2 \mathbf{xopt}_2(k) - \mathbf{H}_{n \neq 2} \mathbf{X}(k))^H \Lambda^{-1} (\mathbf{r} - \mathbf{h}_2 \mathbf{xopt}_2(k) - \mathbf{H}_{n \neq 2} \mathbf{X}(k))$
5
6 wherein j represents one of the 2^n cosets, k represents one of the 2^u labels of coset j , \mathbf{h}_2 is the
7 second column of matrix \mathbf{H} , $\mathbf{H}_{n \neq 2}$ is a matrix of the columns of \mathbf{H} except the second column
8 of matrix \mathbf{H} , Λ^{-1} is an auto-covariance matrix of any of the transmit antennas, and
9 $\mathbf{X}(k)$ represents all rows of matrix \mathbf{X} which have an element of coset k in their 1st column.

1 8. The method of claim 7, further comprising:
2 applying the distance metric and the label metric associated with each
3 transmit antenna to a Viterbi decoder.

1 9. The method of claim 8, further comprising:
2 applying the distance metric and the label metric associated with the first
3 transmit antenna to each of the i^{th} to M_t^{th} transitions in the trellis, wherein i is an integer
4 varying from 0 to $(M_t - 1)$.

1 10. A decoder adapted to receive a vector \mathbf{r} of symbols transmitted in a
2 multi-input multi-output communications system having M_t transmit antennas and M_r receive
3 antennas, said decoder further adapted to receive a channel matrix \mathbf{H} having M_t rows and M_r
4 columns and through which the symbols are transmitted, wherein the vector \mathbf{r} has M_r
5 components, the decoder comprising:

6 a first module adapted to form a first vector quantity \mathbf{xopt}_1 associated with a
7 first one of the transmit antennas and having elements defined by a column \mathbf{h}_1 of matrix \mathbf{H}

8 associated with the first antenna, the remaining columns $\mathbf{H}_{n \neq 1}$ of matrix \mathbf{H} , and a matrix \mathbf{X} of
9 possible symbols transmitted on the remaining ones of the transmit antennas, wherein matrix
10 \mathbf{X} includes $(M_t - 1)$ rows and 2^{u+n} columns, wherein each transmitted symbol is selected from
11 2^n cosets each having 2^u labels, wherein n and u each is an integer greater than zero;

12 a second module adapted to compute a distance metric and a label metric

13 associated with each of the remaining transmit antennas for each coset based on \mathbf{xopt}_1 ;

14 a third module adapted to form a second vector quantity \mathbf{xopt}_2 associated with
15 a second one of the transmit antennas and having elements defined by a column \mathbf{h}_2 of matrix
16 \mathbf{H} associated with the second antenna, the remaining columns $\mathbf{H}_{n \neq 2}$ of matrix \mathbf{H} , and the
17 matrix \mathbf{X} ; and

18 a fourth module adapted to compute a distance metric and a label metric

19 associated with the first one of the transmit antennas for each coset based on \mathbf{xopt}_2 .

1 11. The decoder of claim 10, wherein said first vector quantity
2 \mathbf{xopt}_1 formed by said first module is defined by:

$$4 \quad \mathbf{xopt}_1 = \left[\frac{\Lambda^{-1} (\mathbf{h}_1^* \mathbf{r} - \mathbf{h}_1^* \mathbf{H}_{n \neq 1} \mathbf{X})}{\mathbf{h}_1^* \mathbf{h}_1} \right]$$

5 wherein vector \mathbf{h}_1^* is the complex conjugate transpose of vector \mathbf{h}_1 , and Λ^{-1} is an auto-
6 covariance matrix of any of the transmit antennas.

1 12. The decoder of claim 10, wherein said second vector quantity
2 \mathbf{xopt}_2 formed by said third module is defined by:

$$4 \quad \mathbf{xopt}_2 = \left[\frac{\Lambda^{-1} (\mathbf{h}_2^* \mathbf{r} - \mathbf{h}_2^* \mathbf{H}_{n \neq 2} \mathbf{X})}{\mathbf{h}_2^* \mathbf{h}_2} \right]$$

5 wherein vector \mathbf{h}_2^* is the complex conjugate transpose of vector \mathbf{h}_2 and Λ^{-1} is an auto-
6 covariance matrix of any of the transmit antennas.

1 13. The decoder of claim 10, wherein for coset j , the distance metric
2 computed by the second module and associated with transmit antenna i is defined by:

4 $d(i, j) = \min_k (\mathbf{r} - \mathbf{h}_1 \mathbf{xopt}_1(k) - \mathbf{H}_{n \neq 1} \mathbf{X}(k))^H \Lambda^{-1} (\mathbf{r} - \mathbf{h}_1 \mathbf{xopt}_1(k) - \mathbf{H}_{n \neq 1} \mathbf{X}(k))$

5
6 wherein i represents one of the transmit antennas other than the first antenna, j represents one
7 of the 2^n cosets, k represents one of the 2^u labels of coset j, $\mathbf{H}_{n \neq 1}$ is a matrix of the columns of
8 \mathbf{H} except the first column of matrix \mathbf{H} , Λ^{-1} is an auto-covariance matrix of any of the
9 transmit antennas, $\mathbf{X}(k)$ represents all rows of matrix \mathbf{X} which have an element of coset k in
10 their i^{th} column, and $\mathbf{xopt}_1(k)$ represents those elements of vector \mathbf{xopt}_1 that belong to coset
11 k.

1 14. The decoder of claim 10, wherein for coset j, the label metric
2 computed by the second module and associated with transmit antenna i is defined by:

3
4 $label(i, j) = \arg \min_k (\mathbf{r} - \mathbf{h}_1 \mathbf{xopt}_1(k) - \mathbf{H}_{n \neq 1} \mathbf{X}(k))^H \Lambda^{-1} (\mathbf{r} - \mathbf{h}_1 \mathbf{xopt}_1(k) - \mathbf{H}_{n \neq 1} \mathbf{X}(k))$

5
6 wherein i represents one of the transmit antennas other than the first antenna, j represents one
7 of the 2^n cosets, k represents one of the 2^u labels of coset j, $\mathbf{H}_{n \neq 1}$ is a matrix of the columns of
8 \mathbf{H} except the first column of matrix \mathbf{H} , Λ^{-1} is an auto-covariance matrix of any of the
9 transmit antennas, $\mathbf{X}(k)$ represents all rows of matrix \mathbf{X} which have an element of coset k in
10 their i^{th} column, and $\mathbf{xopt}_1(k)$ represents those elements of vector \mathbf{xopt}_1 that belong to coset
11 k.

1 15. The decoder of claim 10, wherein for coset j, the distance metric
2 computed by the fourth module and associated with the first one of the transmit antennas is
3 defined by:

4
5 $d(1, j) = \min_k (\mathbf{r} - \mathbf{h}_2 \mathbf{xopt}_2(k) - \mathbf{H}_{n \neq 2} \mathbf{X}(k))^H \Lambda^{-1} (\mathbf{r} - \mathbf{h}_2 \mathbf{xopt}_2(k) - \mathbf{H}_{n \neq 2} \mathbf{X}(k))$

6
7 wherein j represents one of the 2^n cosets, k represents one of the 2^u labels of coset j, \mathbf{h}_2 is the
8 second column of matrix \mathbf{H} , $\mathbf{H}_{n \neq 2}$ is a matrix of the columns of \mathbf{H} except the second column
9 of matrix \mathbf{H} , Λ^{-1} is an auto-covariance matrix of any of the transmit antennas, and
10 $\mathbf{X}(k)$ represents all rows of matrix \mathbf{X} which have an element of coset k in their 1st column.

1 16. The decoder of claim 12, wherein for coset j, the label computed by the
2 fourth module and associated with the first one of the transmit antenna is defined by:

3

4
$$label(1, j) = \arg \min_k (\mathbf{r} - \mathbf{h}_2 \mathbf{xopt}_2(k) - \mathbf{H}_{n \neq 2} \mathbf{X}(k))^H \Lambda^{-1} (\mathbf{r} - \mathbf{h}_2 \mathbf{xopt}_2(k) - \mathbf{H}_{n \neq 2} \mathbf{X}(k))$$

5

6 wherein j represents one of the 2^n cosets, k represents one of the 2^u labels of coset j, \mathbf{h}_2 is the
7 second column of matrix \mathbf{H} , $\mathbf{H}_{n \neq 2}$ is a matrix of the columns of \mathbf{H} except the second column
8 of matrix \mathbf{H} , Λ^{-1} is an auto-covariance matrix of any of the transmit antennas, and
9 $\mathbf{X}(k)$ represents all rows of matrix \mathbf{X} which have an element of coset k in their 1st column.

1 17. The decoder of claim 16, wherein said decoder supplies the distance
2 metric and the label metric associated with each transmit antenna to a Viterbi decoder.

1 18. The decoder of claim 10, wherein each of the first, second, third and
2 fourth modules is a software module

1 19. The decoder of claim 10, wherein each of the first, second, third and
2 fourth modules is a hardware module.

1 20. The decoder of claim 10, wherein each of the first, second, third and
2 fourth modules includes both software and hardware modules.